6

The sex life of the whiptail lizard

Introduction

David Crews, a professor of zoology and psychology at the University of Texas, might be thought of as a sexual voyeur. This is because he spends much of his time observing the bizarre sex lives of reptiles such as lizards and snakes. His work is of great interest to biologists. It is sometimes controversial. Our focus in this chapter is on one particular set of observations which Crews made of the mating behaviour of a particular genus of whiptail lizard. However, by way of introduction to the sexual world of reptiles which Crews studies, we will first look at his less controversial work on the red-sided garter snake.

The Arctic environment of western Canada provides perhaps the harshest conditions encountered by any vertebrate on the planet. It is here that the red-sided garter snake lives. In order to survive the long Arctic winter, snakes have learnt the trick of cryopreservation. Their blood becomes extremely thick, and crucial bodily organs stop functioning almost completely, exhibiting barely detectable levels of activity. However, when Spring arrives, they undergo rapid transformation in preparation for mating.

Mating occurs over a short, intense period. The males emerge first from their long winter deep-freeze and spend from three days to three weeks basking in the sun near the entrance to the den. When the females emerge, either alone or in small groups, the males are

attracted by a pherome (a messenger substance) on their backs. Up to 100 males converge and form a 'mating ball'. Once a male succeeds in mating, the others immediately disperse. The mated female, who has been rendered unattractive to other males as a result of a pherome which she has received from the mating male, now leaves the locale. The males regroup, waiting by the entrance of the den for the emergence of other females with which to mate.

Why are biologists interested in such a curious ritual? Crews is a behavioural neuroendocrinologist. He studies the evolution of the systems in the body that control reproduction and sexual behaviour. He uses a variety of techniques, including observations of behaviour, examination of organs, and analyses of substances in the blood. Comparisons are made with other species. The garter snake is of particular interest to Crews because of the way that its sexual behaviour and its physiology are synchronised with the demands of the environment. The snakes' sexual activities may seem strange to us, but they have adapted perfectly to the extreme conditions under which they live. For Crews the behaviour of the garter snakes was a particularly powerful illustration of how environmental factors may influence the evolution and development of various aspects of reproduction. By emphasising the role of the environment Crews can be thought of as taking sides in one of the oldest debates in biology: nature versus nurture.

Crews' interest in reproductive physiology is somewhat at odds with the traditional fields of reptile study. His work falls between the interests of herpetologists who study snakes and lizards from a natural history standpoint and neuroendocrinologists who compare various hormonal control systems without necessarily linking their work to the sexual behaviour of the species. With his interest in evolution and in comparing more than one species, Crews also finds audiences for his work among evolutionary theorists, comparative biologists, zoologists and psychologists. Like many scientific innovators, Crews brings together approaches from a variety of areas that traditionally have gone their separate ways. It is partly because of this that his work has been tinged with controversy. By asking new questions of aspects of the behaviour and physiology of species that have already been well studied, Crews was posing a challenge to the established experts.

Of course, just because a scientist's work challenges that of his or her colleagues, does not mean that it will necessarily lend itself to controversy. Many contentious findings or approaches within science are simply ignored. For instance, numerous papers have been published challenging the foundations of quantum mechanics or relativity theory which scarcely cause a ripple on the surface of physics. Turning a blind eye in the no-nonsense way to deal with potentially troublesome ideas. Indeed, obtaining a controversial status for a set of ideas such that other scientists feel compelled to reject them in an explicit manner is a substantial achievement in itself.

By the time Crews produced his controversial work on the whiptail lizard he was too important a figure to ignore. In the early stages of his career at Harvard there was no inkling of the controversy to come. His approach and findings did not challenge the fundamentals of his field. By the time he moved to Texas University (after seven years at Harvard) he was a highly respected, visible, and well-connected scientist. It was only now, after having established himself, that he started to stress the radical quality of his ideas. The most sharply focussed controversy in which Crews has become involved has not centred on the grander issues of evolutionary theory but on some rather specific claims that he made concerning the sexual behaviour of the whiptail lizard. It is his observations of this vertebrate and their reception which form the backbone of our story.

In what follows we shall be particularly concerned to follow the twists and turns of this one scientific controversy. It may seem perverse to go into such detail. However, we would remind the reader that it is exactly in the detailed arguments that we find the rough diamond of science.

'Leapin' lesbian lizards'

This heading was used by *Time* magazine to introduce Crews' observations of the sexual habits of *Cnemidophorus*, the whiptail lizard. *Cnemidophorus* is unusual in the reptile world because it breeds 'parthenogenetically'. That is to say it can reproduce from the eggs of the female without needing a male to fertilise them. This makes the species ideal for studying aspects of the evolution of

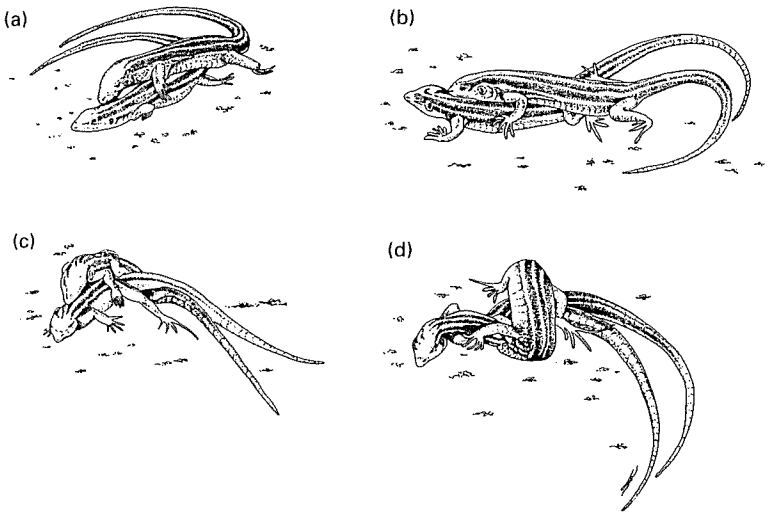

Figure 6.1. Sexual behaviour in C. *uniparens* (redrawn by Steven W. Allison from Myers, 1990, p. 273).

sexuality that cannot be separated and analysed in normal sexual species, where the complicating factor of male heredity is always present.

As soon as Crews started work on *Cnemidophorus* he noticed what at first sight was a bizarre pattern of behaviour. These non-sexual lizards, who did not need to mate, sometimes mounted each other, behaving just like other sexual lizards. It was this observation which previous researchers had ignored, or chosen to ignore, which lies at the heart of the controversy.

The behaviour of significance to our story is reproduced in the series of illustrations shown in figure 6.1. The sequence appears to be simple enough. One active female climbs onto the back of another passive female, curves its tail around its partner's body so that their sexual organs come into contact, strokes the neck and back, and rides on top of the other for one to five minutes. All biologists agree that this is what happens. They disagree over the meaning to be given to the observations.

For Crews and his co-worker Fitzgerald, the lizard's strange

behaviour (repeatedly observed with different lizards) was clearly sexually related. Indeed, they thought that what they had seen was so significant that they presented it as a new and important scientific discovery about parthenogenetic species. The courtship routine followed by the copulatory behaviour seemed remarkably similar to ordinary mating which Crews had observed in other closely related sexual species. Furthermore, dissection and palpation (examining by touch), of the lizards revealed its sexual significance. The courted animal appeared to be reproductively active, 'having ovaries containing large, preovulatory follicles, while the courting animal was either reproductively inactive or postovulatory, having ovaries containing only small undeveloped follicles'. This difference raised general questions about the function of the pseudo-copulatory behaviour for sexuality, such as its possible role in priming reproductive mechanisms.

If Crews thought he had made a major discovery, other biologists were not so sure. Some were outright sceptics. Two of the best-known researchers into this genus of lizard, Orlando Cuellar of the University of Utah, who in the early 1970s had shown the chromosomal mechanisms of parthenogenesis, and C. J. Cole of the American Museum of Natural History, who pioneered the physiological study of the genus, soon disputed Crews' claims. For these scientists, who had spent years studying *Cnemidophorus* and in particular learning how to maintain them in captivity, Crews was an inexperienced upstart. Rather than carefully observing the lizards over lengthy periods, he had, in their view, immediately seized upon a peculiar piece of behaviour, noticed in a very few animals, and blown it up into a sensational claim. Cuellar and Cole may have been particularly irked that *Time* magazine had picked up on the story; the sexual exploits of lizards made for compelling media coverage.

The first response of Cuellar and Cole was to attempt to play down the aberrant behaviour. They claimed that there was nothing particularly novel or surprising going on, since others (including themselves) had observed such activity among lizards before. Also Crews was simply wrong in claiming any general significance for the study of parthenogenetic species. The behaviour he had observed was trivial: it was unnatural and a product of captivity. Moreover a more experienced worker would not have been led astray and would have

chosen to ignore it for the artefact it undoubtedly was. The key issue, then, was whether the lizard's behaviour was an artefact, produced by the overcrowded conditions of captivity, as the critics asserted, or an essential and previously neglected part of reproductive behaviour.

One feature of scientific controversies is that they bring into sharp focus the competence of the protagonists. Normally in science ability is taken for granted. However, in a controversy the specific scientific issues at stake and the abilities of the scientists involved are difficult to disentangle. In the ensuing debate between Crews and his critics the need for all the researchers to establish their skill became paramount.

Much of the controversy has taken place in the published scientific literature and one indication of the increasing importance attached to the establishment of competence is the expansion of the normally brief 'methods' sections of the papers. In Crews and Fitzgerald's original paper the method section was simply a few lines which accompanied photographs of the lizards. However, by the time it comes to rebutting their critics five years later, there is a remarkable amount of detail concerning the regimen of care of the lizards, the observational procedures followed and so on. As the controversy develops, the skills and competence necessary to make these sorts of observation also become an issue. For instance, in his published attack on Crews, Orlando Cuellar refers to his own long experience (over a decade) observing captive *Cnemidophorus* produce eggs, and his 'precise knowledge' of the reproductive cycle. He states that, although he has seen behaviour such as that observed by Crews sporadically on and off for fifteen years in the laboratory, it is insignificant.

In the same way, Cole and Townsend, in a rebuttal of Crews and Fitzgerald, emphasise their own skills as observers, stressing the detail and duration of their observations (in contrast to the short period of Crews and Fitzgerald's work), and the fine-grained nature of their behaviour categorisation system. They even mention where the lizards were kept (in their offices), and that they cared for the animals personally. Again such details never normally appear in routine research reports.

Such personal appeals to a scientist's own skills and reconstructions of the details of everyday work in the lab produce, however, an

unintended effect. They make science look more like other areas of activity which are carried out in the mundane world of offices and which depend on skill.

It is no accident that the routine scientific paper plays down such factors. It is the absence of these discussions which makes science look like a special activity; scientists become merely mediators or passive observers of Nature. Because the establishment of skill and competence becomes important during a controversy we start to see better what goes into the making of science. Processes which are normally hidden become visible.

Ironically when Crews and his colleagues responded to Cuellar they made his appeal to his own diligence and experience count against him. They took his admission that he had indeed seen the pseudo-copulatory behaviour as a confirmation of their own observations. They then went on to treat his failure to realise its significance as stemming from his own preconceptions. This is part of a general strategy which Crews has used against his critics whereby he portrays them as being stick-in-the-mud, paradigm bound, and caught up in the old traditions, rather than seeing what is there to be seen. This 'young Turks' strategy is not unfamiliar in scientific controversy.

Part of the argument concerning competence centres on the carefulness of the observers. In this case the critics claim that Crews and Fitzgerald simply have not been careful enough in their observations. The argument about carefulness, however, like most arguments in a controversy, can cut both ways. This line is taken by Crews and his group in their response to Cole and Townsend; they pick upon an apparent lack of rigour in the methods followed. They note that Cole and Townsend assess the reproductive state of the lizards from a visual inspection of abdominal distension. This, they claim, is inadequate as it is well known that palpation is also needed. In an ingenious move, they actually cite Crews' other critic, Cuellar, in support of this requirement.

Accusations of carelessness are ineffective in resolving disputes because they tend to circularity. Everyone knows that the careful scientist will find the 'truth', while the careless observer gets it wrong. But what there is to find is exactly the point at issue. If you believe pseudo-copulation is a genuine phenomenon then Crews appears to

have been careful and his critics careless; conversely if pseudo-copulation is taken to be an artefact then it is his critics who have been careful and Crews careless. Care, in and of itself, like most such factors in a controversy, cannot provide an independent means to settle the issue. We are back in the experimenter's regress with a vengeance.

If general attributions of skill and competence cannot settle the controversy, what about matters of fact? As we have argued above, matters of fact are inseparable from the skills of the scientist used to produce them. Thus when the critics make a specific claim in an attempt to refute Crews, it is no surprise to find again that issues of competence are never far from the surface. The claim made by Cuellar, and Cole and Townsend, that the copulatory-like behaviour of the lizards stems from overcrowded conditions lies at the core of the controversy. It is answered by Crews in the following way. In his later articles, as mentioned above, he goes into great detail concerning his methods. The exact conditions under which his lizards are kept are given. Having done this, he is able to turn the tables on his critics by claiming that they present no specific data themselves to show that crowded conditions will lead to the artefactual copulation. 'They do not give the dimensions of the cages used, nor the number of animals housed per cage' (quoted in Myers, 1990, p. 125). With this move, it is Crews who appears to have been painstakingly careful in the very area where his critics have chosen to make their attack; the critics, on the other hand, are made to look cavalier in their accusation.

One way in which this controversy in biology appears to differ from the controversies in physics examined in this book is that very few new data are generated during the course of the controversy. The grounds of the debate seem to be constantly switching in the process of trying to find the right interpretation for previous observations. In physics, experiments serve as a way of focussing the debate. In this area of biology, experiments are seldom possible. Rather, attention is constantly drawn to evidence that is missing from the rival side's position – such as the evidence on crowded conditions leading to pseudo-copulation as mentioned by Crews in response to Cole and Townsend.

The most salient piece of negative evidence in the whole debate is

simply that no-one, including Crews and Fitzgerald, has ever seen pseudo-copulation of lizards in the field. Cole and Townsend make much of this point, mentioning that the most thorough study of *Cnemidophorus* in the wild does not include it. As might be expected, Crews' and his group's response is up to the job. Again they turn the tables on the critics. They point out that such behaviour might well occur, but are observations in the wild capable of documenting it? It is well known that *Cnemidophorus* is a very shy species and that even matings in the ordinary sexual lizard are observed infrequently. So where better to observe such delicate phenomena than in captivity!

Love bites and hand waving

Often in the course of a scientific controversy previously ignored minutiae become highly relevant and hotly debated. As both sides try to cast doubt upon the others' arguments, more and more additional pieces of evidence get brought in. In the present case the number of 'love bites' the lizards underwent and whether or not they wave their hands as a sign of sexual submission both became important.

Cuellar argued that in species he had collected in the wild he had rarely seen any 'copulation bites' and more would be expected if pseudo-copulation was routine. The answer Crews and his group gave was again to reverse the argument by pointing out that if Cuellar was right then it would mean that normal sexual lizards were not mating either! The answer, they suggested, was that such bites are not a natural inscription of mating. To try to substantiate their point they examined the corpses of 1000 dead female lizards from a sexual species and found only 3% had marks on their backs and sides and, further, that the same frequency of males possessed such marks. So in this way Crews managed to turn the evidence produced by Cuellar back against him. Marks are most certainly found on dead lizards, but as they are found on males as well they are probably produced by aggressive behaviour.

Hand waving became significant in a postscript added by Cole and Townsend to their rebuttal of Crews. They criticise Crews for 'erroneously' relying on the lizards' lifting of the hand as an

indication of submissiveness. Instead, according to them, it is merely a sign that the lizard is basking. Again it is the competence of the researchers which is under attack. A researcher who cannot tell basking from hand waving has a credibility problem. Although Crews does not seem to have responded in public to this particular criticism, from what has gone above the reader can speculate about the possible lines of argument Crews could have adopted in defence.

An honorable draw

So where does this controversy stand today? The current consensus is that Crews and his critics have battled to an honorable draw. Both sides have given their version of the endocrinology of *Cnemidophorus* in separate articles in the *Scientific American* and both continue to work within their rather different approaches.

The even-handed view which we have presented as we have followed the twists and turns of the debate is not likely to be shared by the protagonists. Their own arguments and positions are, of course, compelling, indeed irresistible to them. In presenting a neutral account we risk disappointing both sides.

Many scientists are wary of getting entangled in controversies and perceive them to be the repository of shoddy science. This can mean that denying you are party to a controversy can itself be a tactic in such disputes. We see it happening in the lizard controversy. In writing their articles in *Scientific American* both sides avoided any explicit reference to the controversy at all.

One way to close down a controversy is to rewrite history such that the dispute seems premature: an over-reaction of an under-developed field. Crews, in particular, in his later writing has presented his first paper and the reaction to it as having this character. For Crews it was an unfortunate debate which was characterised by a lack of firm experimental tests and decisive evidence. By appealing to the rhetoric of experiment and testing, something to which his methodology of working with lizards in captivity is ideally suited, Crews can appear to have found a way to have advanced beyond the earlier controversy. Whether this rhetoric succeeds remains to be seen.

One question has been left unanswered. Do *Cnemidophorus*

lizards indeed exhibit pseudo-copulatory behaviour which is relevant to their reproduction? Despite five years of research and debate the answer appears to be that we do not know. According to one group of respected scientists they do; according to another group they do not. As always the facts of nature are settled within the field of human argument.